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Effect of organic and inorganic nutrient sources on yield attributes of African marigold

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Abstract

Marigold holds significant cultural and religious importance, making them widely cultivated flowers in Nepal. However, its yield remains comparatively low due to the loss of nutrients through leaching and volatilization, which diminishes nutrient availability and soil fertility. This study aimed to identify an appropriate nutrient source for higher flower yield in marigolds while ensuring sustainable soil health by providing essential nutrients to the soil. For this, a field experiment was conducted in Biratnagar, Morang, Nepal in a Randomized Complete Block Design (RCBD) with four replications and five treatments. The treatments include Recommended Dose of Fertilizers (T1), 75% Recommended Dose of Fertilizers (T2), 125% Recommended Dose of Fertilizers (T3), Poultry Manure (T4) and Vermicompost (T5). Vermicompost (T5) demonstrated superior performance, with the tallest plants (19.25 cm at 24 DAT, and 58.48 cm at 69 DAT), the highest fresh flower weight (7.4 g), and maximum flower yield (12.54 t ha^{-1}). Similarly, T2 (75% RDF) resulted in significantly taller plants (52.88 cm) at 54 DAT. T3 (125% RDF) promoted highest number of branches (17.53) at 54 DAT. T1 had the thinnest stem diameter at 24 DAT, whereas other treatments were on par with each other. No significant differences were observed at days to first flowering. Vermicompost was observed as the most effective nutrient source, which significantly improved the growth and yield of marigold when compared to poultry manure and chemical fertilizers. Hence, the farmers in Biratnagar Metropolitan City are recommended to use vermicompost for higher and sustainable yield, along with sustainable soil health

Keywords: Marigold, Fertilizers, Organic nutrients, Growth, Yield

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INTRODUCTION

Marigold is a plant that has been grown for a long time. It is loved not just for its bright flower color, but also for its diverse uses in different areas. It is mainly used for decorative purposes and is popular in gardens and landscapes. Marigold plants are not only important for their ornamental value, but also for their applications in medicine, industry, and agriculture. They are used in traditional medicine for their anti-inflammatory, antimicrobial, and wound-healing properties (Singh et al., 2004). The African marigold is a key flower in Nepal, and it is loved for its crucial role in culture and traditions. It comes in many colors, shapes, and sizes. Furthermore, its fragrance is long-lasting, and it is the reason that most people prefer it (Bhosale & Gobade, 2025). Growing marigold is easy because of their rapid growth in nature and short gestation period. They are mostly used for cut purpose all over the world (Singh et al., 2015). In South Asia, people use marigolds for making garlands, decorating places, and improving garden's view. They also use them in many religious and social events (Dixit et al., 2013). Marigold also acts as repellent for bugs, insects and mosquitoes. It is also used in chicken feed, as it helps egg yolks become yellow. People also plant them for the management of pests such as tomato bugs. In addition, oils extracted from marigold is used in perfume industries (Singh et al., 2015). Nepal's need for flowers is big and

growing, but it cannot grow enough on its own, and hence, is imported from countries such as India and China. The peak demand for marigold in Nepal is during festive seasons in Autumn, on the occasions such as Dashain and Tihar. However, due to improper timing of the plantation of this crop, most people cannot harvest flowers at the right time (i.e. during the festive season), and hence, the flower has to be imported (Dhakal & Bhattarai, 2017). Nepal imports around 150,000 marigold garlands during Tihar, spending NRs. 8,100,000 on marigold flowers (FAN, 2013). Tihar, a major festival in Nepal (widely known as Diwali in India), involves worshipping different animals over its first four days. On the fifth and final day, sisters perform rituals for their brothers to protect and bless them.

Among several genera of marigold, African marigold (*Tagetes erecta*) and French Marigold (*Tagetes patula*) are common worldwide among people (Kumar et al., 2015). The French Marigold is one of the sub-species of the African Marigold. Beyond its use in landscaping, African Marigold is also cultivated extensively for its loose flowers, which are commonly used in religious and cultural ceremonies and garland-making (Kumar et al., 2019, Patel et al., 2019). As one of the most important herbaceous annuals, French Marigold is commonly used in flower beds (Cicevan et al., 2016). The African Marigold grows upright, producing large flower heads measuring 7-12 cm, and blooms 80-90 days after planting. In contrast, the French Marigold forms compact clumps with smaller flowers, about 3-6 cm in diameter, and flowers earlier, within 30-55 days after sowing (Zhang et al., 2022).

In Nepal, traditional farming practices dominate, and the use of fertilizers is often based on inherited knowledge rather than scientific research. This leads to inconsistent yields and suboptimal plant health, which directly impacts the economic returns for farmers. There is an abundance of organic manures available in Nepal, which are cheap and effective. These not only improve soil health but also improve plant growth (Acharya et al., 2020). However, the nutrient content and release rates of organic manures can be highly variable, leading to inconsistent results. On the other hand, inorganic fertilizers help provide exact nutrients immediately to plants such as potassium, zinc, nitrogen, phosphorus, and many more nutrients for quick growth and bloom in marigold plants. However, they are expensive and unsustainable because of the number of chemical residues left behind in the land (Marschner, 2012). Fertilizers are crucial for the rapid growth and flowering of marigold plants but can be costly and may have adverse environmental impacts if not used judiciously. When organic and inorganic sources of nutrients are mixed, marigold's production increases, along with positive results in soil health (Chaupoo & Kumar, 2021). However, research related to organic manures and inorganic fertilizers is done very rarely in Nepal. This is because marigold cultivation is primarily confined to the summer and autumn seasons in Nepal. Furthermore, successful production during winter and spring has not yet been achieved due to challenges such as low temperatures, and insufficient light intensity (Dhakal et al., 2021). In addition, most of the researchers from universities, research centers, NGOs and INGOs prioritize other cereal and vegetable crops because of their importance in food security. Hence, due to these reasons, there are only a limited number of researches in the floriculture sector.

Understanding the comparative effects of organic and inorganic fertilizers on the morphological growth and yield of marigolds is crucial for farmers, agricultural advisors, and policymakers. Such knowledge can aid in developing sustainable agricultural practices that optimize crop yield and quality while preserving soil health and environmental integrity (Yadav et al., 2024). Moreover, the export potential of marigolds could be improved drastically because of their cultural and religious importance in the neighboring country, India, when proper research on marigolds is prioritized in Nepal. The rationale for this study is to provide a comprehensive comparison of the effects of organic and inorganic fertilizers on the morphological growth and yield of marigolds in Nepal. By evaluating various growth parameters and yield outcomes, this research aims to identify the most effective fertilization strategy for marigold cultivation that balances immediate productivity with long-term soil health and sustainability.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out in the farmer's field located in Rajbanshi Chowk, Biratnagar, Nepal from March to June 2024 to find out the effect of organic and inorganic nutrient sources on morphological and yield attributes of *Tagetes erecta* L. Geographically, it is located at 26°27'15" N and 87°16'47" E, where the climate is tropical with an elevation of 80 meters above sea level.

Experimental Design

Randomized Complete Block Design was used for the field experiment where five different treatments were replicated four times. The treatment details are given below in (Table 1). Calcuttia Orange variety of African marigold was used for the field trial. The individual plot was 2 m × 1.8 m. The spacing was kept at 40 cm × 30 cm with a total number of 30 plants per plot (Nain et al., 2017). 5 random plants per plot were selected and tagged for recording data. The nutrient sources for T1, T2 and T3 were chemical fertilizers with a dose of 100% RDF, 75% RDF and 125% RDF respectively. Similarly, the nutrient sources for T4 and T5 were organic and received poultry manure and vermicompost respectively. A full dose of P and K and a half dose of N were applied in T1, T2 and T3 during field preparation. The remaining half dose of N was applied as top dressing 30 days after transplanting. Soil sampling and analysis were performed, and the results are given below in (Table 2).

Table 1. Treatment details

SN	Treatments	
T_1	Recommended dose of NPK (45: 90: 75 N: P_2O_5:K_2O kg/ha)	(Tnau, 2009)
T_2	75% of the recommended dose of NPK (33.75:67.5:56.25 N: P_2O_5:K_2O kg/ha)	(Divya et al., 2017)
T_3	125% of the recommended dose of NPK (56.25:112.5:93.75 N: P_2O_5:K_2O kg/ha)	(Divya et al., 2017)
T_4	Poultry manure (3.16t/ha)	(Dikr and Belete,2017)
T_5	Vermicompost (5t/ha)	(Dikr and Belete,2017)

Table 2. Soil chemical and physical properties

Parameters	Units	Analysis result
pH		5.7
Total nitrogen	%	0.010
Available P205	ppm	165.000
Available K205	ppm	263.000
Soil organic matter	%	0.150
Textural class		Silty loam

Climatic conditions

The recorded highest temperature was 40°C in April and May, whereas the minimum temperature was recorded 15°C in March. The highest amount of rainfall was recorded during monsoon season, i.e. June and July, with records of 27 cm and 15 cm respectively. The climatic information is shown in the (Figure 1). There was no research during July, which is represented below, and hence, the climatic data for July can be neglected.

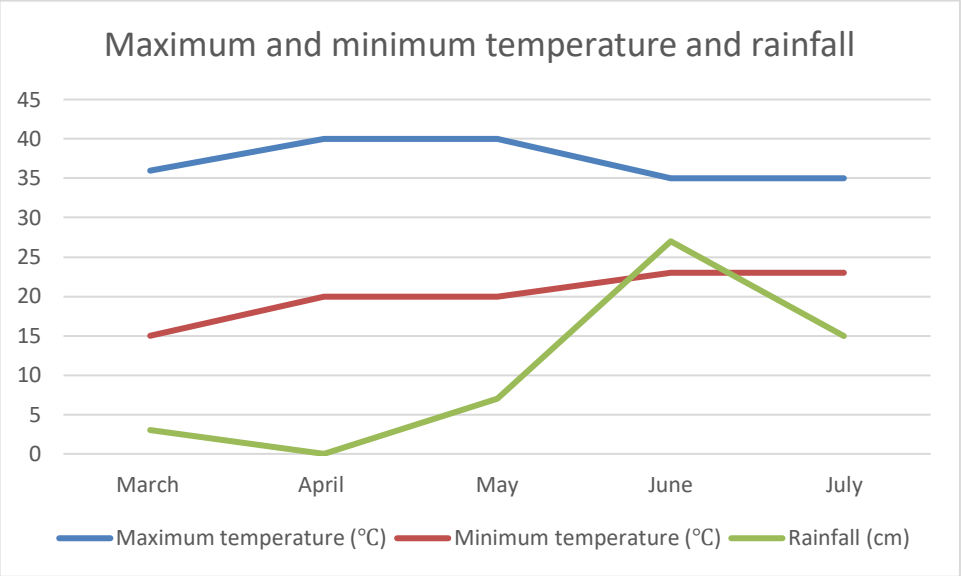

Figure 1. Maximum and minimum temperature and rainfall of the experimental site

Field preparation and irrigation

A deep plow of the land with a 4-wheel drive tractor-driven cultivator was executed after the previous crop was harvested. 2-3 harrows were done after deep ploughing. The clods were crushed and made fine tilth with a spade. The whole land was leveled properly. Stubbles, weeds and pebbles were removed clearly from the experimental plot. The plots were slightly raised to avoid water logging during monsoon. A furrow was dug around the trial plot to provide proper drainage during rainfall. Marigold plants require adequate moisture throughout their growth period. The first irrigation was performed immediately after transplanting. When the plants are small, frequent water is necessary in the root zone, and hence, irrigation was done daily based upon the weather conditions.

Statistical analysis

Data entry and processing were carried out using Microsoft Excel. Analysis of Variance (ANOVA) and mean estimation were performed using R-studio version 4.1.1. The treatment means were compared by Duncan's Multiple Range Test (DMRT) at a 5% level of significance.

RESULTS AND DISCUSSIONS

Plant height (cm)

Plant height is a key indicator of vegetative growth and overall plant health. Significant differences were observed in plant height at 5%, 0.1% and 1% levels of significance at 24, 54 and 69 DAT. The maximum plant height at 24 days after transplanting was recorded from vermicompost application (19.25 cm) as shown in (Table 3). Similarly, at 39 DAT, plant height is non-significant. At 54 DAT the maximum plant height was seen in the plot with 75% of the recommended dose of NPK (52.88 cm). At 69 DAT, though there were not any significant differences between vermicompost and 75% of the recommended dose of NPK, pots fertilized with vermicompost had taller plants (58.48 cm).

The results of Dikr and Belete (2017) are in conformity with this research. Vermicompost made plants grow tall from the start to the end days. This is because, it helps take more nutrients such as nitrogen from the sub-soil, which lets chlorophyll accumulate in the leaves for photosynthesis. Additional studies by different researchers support this observation, emphasizing that organic amendments improve soil structure, water retention, and microbial activity, which collectively enhance plant growth (Arancon et al., 2003). Vermicompost facilitates plant growth by offering increased nutrient availability (Dikr and Belete, 2017).

Table 3. Effect of organic and inorganic nutrient sources on plant height of African marigold

Treatment	Plant height (cm)			
	24 DAT	39 DAT	54 DAT	69 DAT
Recommended dose of NPK	16.9^{c}	26.95	38.45^{b}	46.95^{b}
75% of the recommended dose of NPK	17.5^{bc}	28.45	52.88^{a}	54.25^{a}
125% of the recommended dose of NPK	18.2^{ab}	30.1	40.45^{b}	47.45^{b}
Poultry manure	18.55^{bc}	27.9	37.25^{b}	45.65^{b}
Vermicompost	19.25^{a}	30.95	40.33^{b}	58.48^{a}
F-test	*	ns	***	**
SE(m)	0.18	0.56	0.77	00.96
LSD	1.23	5.68	5.33	6.64
Grand mean	18.08	28.87	41.87	50.55

Note: ns: non-significant ***Significant at 0.1% level; **Significant at 1% level; * significant at 5% level; SE(m): Standard error of mean; Value with same letter(s) in a column are not significantly different at 5% level by DMRT.

Stem diameter

Stem diameter is crucial to plants because it helps plants withstand extreme external forces such as storms and animals. There was a significant difference in plant stem diameter at 24 DAT, with a significance level of 5%. The highest stem diameter at 24 days after transplanting (DAT) was recorded from 125% of the recommended dose of NPK as shown in (Table 4). The stem diameter was non-significant at 39 DAT, 54 DAT and 69 DAT, but most of the treatments at 24 DAT were at par. Even though the treatments were insignificant at 39 DAT, the one with a 125% NPK dose had the thickest stem. This is because of the higher nutrient availability at the initial stages of plant growth.

Dikr and Belete (2017) & Singh et al. (2015) found the same result regarding the effect on stem girth by NPK fertilizer. They recorded that the right amount of NPK made the stems wider. Furthermore, nitrogen helped the plants grow more, phosphorus helped the roots, and potassium made the plants stronger and steadier. Similarly, a proper dose of nitrogen, phosphorous and potassium to plants improve their vigor and growth, along with structural integrity (Brady & Weil, 2008).

Table 4. Effect of organic and inorganic nutrient sources on stem diameter of African marigold

Treatment	Stem diameter (mm)			
	24 DAT	39 DAT	54 DAT	69 DAT
Recommended dose of NPK	2.1^{ab}	7.25	10.24	12.74
75% of the recommended dose of NPK	4.35^{a}	7.30	10.18	12.25
125% of the recommended dose of NPK	5.24^{a}	7.95	10.16	11.75
Poultry manure	4.98^{a}	7.40	9.94	11.25
Vermicompost	4.32^{a}	7.71	9.89	12.45
F-test	*	ns	ns	ns
SE(m)	0.31	0.18	0.22	0.26
LSD	2.10	1.26	1.53	1.79
Grand mean	4.20	7.52	10.08	12.09

Note: ns: non-significant ***Significant at 0.1% level; **Significant at 1% level; * significant at 5% level; SE(m): Standard error of mean; Value with same letter(s) in a column are not significantly different at 5% level by DMRT.

Number of branches

The number of branches in a plant is very important because of its proportionality to the yield. It was non-significant at 39 DAT and 69 DAT. However, at 54 DAT, a significant difference with a significance level of 5% was observed. The plot with 125% of the recommended dose of NPK (17.53) recorded the highest number of branches. Except for this treatment, the other treatments were at par, meaning that there were not any significant differences between those treatments (Table 5).

Regarding the number of branches each plant had, the plots with 125% of NPK had more branches. Sinha & Tandon (2020) indicated that nitrogen is important for branch development, phosphorus fosters the health of roots, and potassium enhances overall plant stability. Similarly, Marschner (2012) stated the role of macronutrients in the regulations of hormones, which is essential for branch development. Hence, a higher supply of nutrients fosters the development of branches in the plants.

Table 5. Effect of organic and inorganic nutrient sources on number of branches of African marigold

Treatment	Number of branches		
	39 DAT	54 DAT	69 DAT
Recommended dose of NPK	11.50	14.05[b]	13.63
75% of the recommended dose of NPK	12.15	13.53[b]	12.87
125% of the recommended dose of NPK	13.70	17.53[a]	15.65
Poultry manure	12	13.65[b]	14.15
Vermicompost	11.80	14.40[b]	14.06
F-test	ns	*	ns
SE(m)	0.28	0.35	0.60
LSD	1.91	2.42	4.13
Grand mean	12.23	14.63	14.07

Note: ns: non-significant ***Significant at 0.1% level; **Significant at 1% level; * significant at 5% level; SE(m): Standard error of mean; Value with same letter(s) in a column are not significantly different at 5% level by DMRT.

Phenological and yield traits

There was no significant difference among treatments in the case of days to first flowering. This was also seen in the results by Singh et al. (2015) and Dikr and Belete (2017) (Table 6).

However, a significant difference at a 0.1% significance level was observed in the case of fresh-weight of flowers. The plots treated with vermicompost were seen superior in the case of both the fresh weight of flowers (7.4 grams) and the total yield (12.54 t/ha) during the cropping season. In the case of the individual weight of flowers, all other plots except for the one treated with vermicompost were on par. This result is similar to that of Singh et al. (2015). They found that plots with vermicompost had higher flower weight. Vermicompost has many key things plants need, such as nitrogen, phosphorus, potassium, and other micronutrients. It becomes efficient and convenient for plants to consume nutrients from such sources (Saranraj & Stella, 2012). Moreover, Arancon et al. (2006) demonstrated that vermicompost improves soil microorganism's population, which helps in the proper utilization of nutrients and improves plant productivity.

Similarly, there was a significant difference in flower yield at a significance level of 1% among treatments. The plots with RDF had the lowest yield, but it was also on par with the plots fertilized with poultry manure and 75% of RDF (Table 6). The highest yield was obtained from the plots treated with vermicompost. The plots with vermicompost gave out the highest yield than the ones with 125% of the advised NPK. This finding was also noted by Singh et al. (2015) and Dikr with Belete (2017). Gupta et al. (2014) indicated that vermicompost releases nutrients slow and steadily, which promotes vegetative and reproductive (floral) development. Moreover, Edwards et al. (2011) reported that vermicompost improves soil aeration and root development, which are directly linked with higher yield.

The recommended dose of NPK did not perform satisfactorily, due to leaching and volatilization. Nitrogen loss is a significant problem, which not only impacts plant's performance but also affects the environment negatively (Roosta & Schjoerring, 2007). Furthermore, though poultry manure is organic, a lower yield was observed because of nutrient imbalances and saline conditions. Though poultry manure fosters the growth of plants, its performance is limited in comparison to organic and inorganic fertilizers. In addition, the high amount of ammonia in poultry manure damages the root, which limits nutrient uptake (Pan et al., 2016).

Table 6. Effect of fertilizer on phenological characters at different days in Biratnagar, Morang, 2024

Treatment	Phenological characters		
	Days to first flowering	Fresh weight of flower (gm)	Yield(t/ha)
Recommended dose of NPK	52.25	3.20[b]	3.97[c]
75% of the recommended dose of NPK	55.75	3.13[b]	5.63[bc]
125% of the recommended dose of NPK	53.50	2.93[b]	9.12[ab]
Poultry manure	55.50	2.30[b]	6.90[bc]
Vermicompost	55	7.4[a]	12.54[a]
F-test	ns	***	**
SE(m)	0.45	0.15	0.52
LSD	3.09	1.07	3.61
Grand mean	54.40	3.79	7.62

Note: ns: non-significant ***Significant at 0.1% level; **Significant at 1% level; * significant at 5% level; SE(m): Standard error of mean; Value with same letter(s) in a column are not significantly different at 5% level by DMRT.

CONCLUSION

Based on the results from above, vermicompost performed satisfactorily. It resulted in superior plant height, stem diameter, fresh weight of flowers and total yield of flowers. Furthermore, it supplied nutrients to plants slow and steadily, lowering the leaching and volatilization effect. Such leaching and volatilization problems are common in the case of inorganic fertilizers. In addition, vermicompost does not contain ammonia in excess amount, like that of poultry manure. The excess amount of ammonia is the reason for the low production of flowers by poultry manure in this research. Hence, given its outstanding performance, vermicompost is recommended for local farmers and residents across the district. Its consistent nutrient release and environmentally friendly nature make it a sustainable choice for improving marigold production.

Compliance with Ethical Standards

Peer-review

Externally peer-reviewed.

Declaration of Interests

The authors declare that there is no conflict of interest.

Author contribution

Melina Rai: Conceptualization, Methodology, Software, Formal Analysis, Investigation, Resources, Data curation, Writing- Original Draft, Writing- Review & Editing, Visualization, Project administration. **Krishna Dahal:** Conceptualization, Methodology, Validation, Visualization, Supervision, Project administration. **Khem Raj Ghimire:** Methodology, Investigation, Resources, Writing- Original Draft, Writing- Review & Editing, Visualization. **Supriya Niroula & Uma Devi Bhandari:** Methodology, Investigation, Resources, Project administration. **Soniya Koirala, Chandani Sunuwar & Lilam Karki:** Methodology, Investigation, Resources.

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